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ABSTRACT

Presented is a study reporting the findings relevant to the amount of variation of eleventh- and twelfth-grade students in taking science courses. The findings are reported in terms of ability level (I.Q. scores), socio-economic status (father's occupation), eighth-grade academic grade-point average, and specific science grade in the eighth grade. The magnitude of the contribution of sex role in predicting eleventh- and twelfth-grade entry into science courses, alone and when combined with I.Q., and socio-economic status and achievement in eighth grade are discussed. (Author/SA)

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THE MAGNITUDE OF SEX ROLE INFLUENCE ON ENTRY INTO SCIENCE CAREERS*

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ABSTRACT

The Magnitude of Sex Role Influence on Entry into Science Careers

A recent survey by the National Academy of Science found that less than 10% of the professional scientists in the United States are women. This can, in part, be attributed to many females' lack of early academic training in the sciences. Recent research suggests that sex role is clearly an important predictor of interest in and later entry into science career training programs, over and above that which can be explained by certain commonly used career predictors such as ability, academic achievement, or social class. This research provides a measure of the magnitude of the contribution of sex role to explaining student entry/non-entry into optional science courses in the 11th and 12th grades in addition to that which can be explained by these basic background variables.

Data on the 582 students in this study were taken from a 5-year longitudinal study. Taken together, IQ score, socio-economic status, 8th grade GPA, and 8th grade science grade accounted for 19% of the variance in science entry 3-4 years later. The addition of the variable sex to the model increased the R^2 to 27%. Analysis also indicated that assumed early science ability differences between males and females did not account for their differences in science course-taking in the 11th and 12th grades. Females indeed received somewhat higher science grades than males.

The Magnitude of Sex Role Influence on Entry into Science Careers

Recent research suggests that sex role is clearly an important predictor of interest in and later entry into science career training programs, over and above that which can be explained by certain commonly used career predictors such as ability, academic achievement, or social class (Erlick & LeBold, 1975; Epstein & McPartland, 1977; Kaminski & Erickson, 1978; and see reviews by Fox, 1976; Fennema, 1976; Tobin, et. al., 1976; Kaminski, 1978; Fish, 1978). What this research has not provided, however, is an estimate of the magnitude of sex role influence over and above that which can be explained by these basic background variables.

In this study we report our findings relevant to the amount of variation in whether or not students take elective science courses in the 11th and 12th grades which is explained by their ability level (as measured by IQ scores), socio-economic status (father's occupation), 8th grade academic grade-point average and specific science grade in the 8th grade. We then report our findings on the magnitude of the contribution of sex role in predicting 11th and 12th grade entry into science courses, alone and when added to the students' IQ, SES and 8th grade achievement levels. In this way we are able to provide an estimate of the contributions of sex role to one area of career development. The above mentioned research elaborates on some of the specific sex-related variables used to explain entry into science.

The Problem

A recent survey by the National Academy of Science (1974) found that less than one-tenth of all the professional scientists in the United States

are women.[1] In part, this has been attributed to a variety of career barriers. For example, the heavy time and commitment demands required of a scientist make combining a family with a career in science difficult (Rossi, 1965). Personality characteristics of actual scientists -- high spatial and mathematical aptitudes, independence, low interest in social activities (without accompanying guilt), and preference for working with things rather than people -- tend to be those attributes traditionally associated with the male role rather than the female role in our society (Rossi, 1965; Bachtold & Werner, 1970; Helson, 1971). Other obstacles facing the woman scientist include a shortage of professional role models; lack of sponsorship, professional socialization, and informal signs of belonging and recognition by colleagues; a "climate of unexpectation"; inadequate access to specialized equipment and colleagues necessary in an ever-advancing, fast-moving profession; inferior responsibility, advancement and salary rewards; temporal and geographic career interruptions for the married woman scientist; and inability to select the optimal location for one's specialty and mobility (White, 1970; Epstein, 1972; Bunting, 1965; Perrucci, 1970).

However, a major reason why females are under-represented in the scientific professions is that women as a whole are less well-prepared academically for entry into science. For example, in 1976 women earned 22% of the bachelors' degrees in the sciences (vs. 46% of all bachelors' degrees), 15% of the masters' degrees in science (vs. 46% of all masters'), and 11% of the doctoral degrees in the sciences (vs. 23% of all doctoral degrees) (National Center for Educational Statistics, 1977). But most women are not making these decisions on

[1] For this paper, the term "science" includes the natural and physical sciences, mathematics and the computer sciences as well as engineering. The behavioral sciences are not included because women are somewhat more represented in these fields and because career development patterns differ in this area.

whether or not to pursue science careers at the college level.

Unlike many career fields such as sales or elementary education, the physical and natural sciences as well as mathematics and engineering require commitment to and entry into specific courses of study at a relatively early age. For example, graduate work in physics requires having done considerable undergraduate work in the area, and this, in turn, generally necessitates having had adequate preparation in physics and mathematics in high school. The students must thus make an important decision in their high school years which will limit or expand their possible future career choices. Studies have indeed supported this -- the average social scientist elects his or her career at the undergraduate level, the physical scientist generally does so during high school or earlier (Clark, 1957). Research has also shown that interest in science is generally crystalized by the middle of the high school years and often much earlier, especially for boys (Tyler, 1964). Very few men or women move into the science fields at the college level, any movement is generally out of the sciences. Astin (1963), for example, found that, of the students leaving college with science majors, 92% had entered college as science majors, 6% had been uncommitted, and only 2% had begun college with other majors. Often scientific creativity in later high school could be predicted as early as the 7th grade (Chambers, 1964).

Hence, campaigns to encourage college-age women to enter the sciences can only help those women already adequately prepared in mathematics and science at the secondary school level when these courses become optional electives. And surveys have shown that when these courses become elective, females are much less likely to take them than males are, particularly at the advanced levels of mathematics and science (Erlick & LeBold, 1975;

Fennema, 1976; Kaminski, 1975,1978). For example, one widely quoted study found that 57% of the male college freshmen at Berkeley, but only 8% of the female freshmen had taken 4 years of high school mathematics (Sells, 1973). For this reason, this research centers on sex differences in student entry into advanced optional science courses in the 11th and 12th grades.

Probably the most widely used variables for predicting a variety of academic and career outcomes are ability (as measured by IQ tests), academic achievement and socio-economic status. These have been included in the model investigated in this study to examine their contribution to explaining entry into optional science courses.

Past research suggests that these variables are related to science entry and performance. For example,in their national sample, Erlick & LeBold (1975) found that those high school students who were considering math/science/engineering careers were more likely to have well-educated fathers, and high academic achievement in general as compared with the non-science students. James (1972) found that high academic achievement was one important variable distinguishing between those college females interested in science and those who weren't. Other studies have found that both social class and IQ were related to students' likelihood of electing an advanced course in mathematics or science in high school (Kaminski, 1975, 1978). Social class and general ability level seem to be more important to males' science decisions than females', however (Kaminski, 1978). Bridgham (1972), for example, found that for males, the best predictor of whether the student would take physics was his father's occupational level and his average non-science grades; for females these were somewhat less important. Werts (1966) also reports that, in a national sample of college freshmen, social class did affect career preferrences, particularly for males.

It also seemed important to include some indicator of student ability/performance in science for comparison purposes -- hence students' course grades in science in the 8th grade were used. One commonly held assumption is that females are less likely to go into science careers and courses because they aren't as capable as males in this area. Although course grades may reflect certain student characteristics in addition to ability (e.g. classroom behavior, rule following, motivation, interest, effort), they are probably often interpretted by students, teachers, parents and peers as rough measures of student ability in various areas since they are a tangible and frequent source of academic feedback for particular subject areas. Hence they would probably by used in future decision-making.

Student science grades were taken from the 8th grade for several reasons. In this grade all students took a required science course (as opposed to later specific courses in their academic track). Also, it is at this age that females supposedly fall behind males in mathematics and science ability (Maccoby & Jacklin, 1974; Hilton & Berglund, 1974). For example, on the National Assessment of Educational Progress tests, boys and girls did about equally well in math and science at age 9, but by age 13, girls fell behind, with the gap between the sexes increasing in adulthood (Forbes, 1975). (However, if results from the biological and physical science sections of the tests are separated, there is only a sex difference for the physical sciences (Mullis, 1975)). Suydam & Riedesel's review also concluded that "from junior high school and beyond. . .boys now surpass girls in studies involving science and mathematics" (1969:129 in Fennema, 1977). High school students themselves are also likely to see boys as better in science (47% said boys do better, 5% said girls do better) if they see one sex as superior (48% said "no difference") Ernest, 1975).

For an elaboration and discussion of various specific sex-related factors important in explaining females' lesser performance and particapation in mathematics and science at the college and pre-college levels see reviews by Fox, 1976; Fennema, 1976; Sherman, 1976; Tobin et. al., 1976; Fish, 1978; Kaminski, 1975,1978; Tobias, 1976; Ernest, 1976.

Procedures

The data were taken from a longitudinal study conducted by Brookover and associates (1967) which followed an entire city's cohort of students (the high school class of 1966) from the 8th through the 12th grades. Data were not available for students in special education programs. Complete questionnaire and school record data were available for 684 students during the entire five year period (the original 8th grade N approximately 1700). A final sample of 592 students were selected from the 684 possible students in order to have a dependent variable (entry into science in the 11th or 12th grade) which was not skewed. (A random selection of 296 students out of the 388 who had taken a science course were used along with the entire 296 who had not taken science). Of these, 343 were female, 249 were male.

The variables used here include the following:

General Ability Level (IQ score) - taken from the most recent score reported on the students' school records (ranging from 063 to 147)

Socio-economic Status (SES) - using the Duncan (1961) occupational prestige rating, the occupation of the student's father (or whomever supported the family) was coded 02 through 96

General Academic Achievement (GPA) - student's overall grade point average in the 8th grade was used

Science Achievement (Science Grade) - the science grade which the student received in the 8th grade (the last year when all students took the same science course) was used

Sex Role (Sex)- treating this variable in dummy variable fashion for the regression analysis, males were coded 0 and females were coded 1

Entry into Science - students were coded with a 0 or 1 as to whether they had completed an optional elective course in science in the 11th or 12th grade - before sampling the 592 students out of the 684 (to eliminate the skewed dependent variable as indicated above), 45% of the females and 71% of the males had taken an optional science course; after this sampling procedure these percentages dropped to 39% of the females and 65% of the males

Correlations, regression analyses and percentage tables were used in order to examine the data.

Findings

Table 1 presents the correlations among the variables of concern in this study. Note that all 5 independent variabels -- ability, social class, 8th grade achievement levels (in general and for science) and sex -- are correlated with student completion of elective science courses in the 11th or 12th grade. (The negative correlation between sex and completion of a

Table 1. Correlation Matrix for Sex, IQ, SES, GPA (8th grade), Science Grade (8th grade) and Completion of a Science Course (11th or 12th grade).

	Sex	IQ	SES	GPA	Sci.Gr.
IQ	-.006	--			
SES	.065	.276	--		
GPA (8th)	.149	.526	.270	--	
Science Grade (8th)	.083	.439	.268	.856	--
Completed Science Course (11th or 12th)	-.257	.341	.228	.388	.377

science course should be interpretted as negative from the female perspective). Another aspect of this table which should be noted is that the variable sex is not strongly correlated with IQ or SES, as one might expect, and has only

a small correlation with the academic achievement measures (i.e., females tecn to have slightly higher grades than males do in the 8th grade - even in science courses). As such, sex can be expected to make a fairly unique contribution to the prediction of entry into later elective science courses not accounted for by the other variables.

When correlations are re-computed for males and females separately, an important difference arises. The correlations amoung IQ, SES, GPA and Science Grade are similar for amles and females. However, as shown in table 2, each of these independent variables has a much higher correlation with science entry for males than for females.

Table 2. Separate Male and Female Correlations for IQ, SES, GPA (8th) and Science Grade (8th) with Completion of a Science Course (11th or 12th).

correlations of "Completion of a Science Course" with:	IQ	SES	GPA*	Science Grade*
Females	.303	.206	.350	.310
Males	.417	.323	.578	.551

*Significant Sex Difference -- $p < .05$

Table 3 presents 4 regression models (treating Sex and Completion of Science in dummy variable fashion) used to explain students' entry into optional science courses in the 11th or 12th grades. Model 1 shows that ability (IQ), social class (SES) and academic achievements (general GPA and specific science grade in the 8th grade) together account for 19.4% of the variance in entry/non-entry into science. By adding the variable sex to the model (see model 2), an additional 9.1% of the variance in science entry in the 11th and 12th grades can be explained -- a significant increase.

Because general academic achievement was highly correlated with science grade (.856), GPA was dropped from the regression predictors in models 3 and 4.

Table 3. Full and Restricted Multiple Regression Models (R^2's) Measuring the Contribution of Sex (F's) to Explaining "Completion of a Science Course" (11th or 12th grade) Over and Above the Contribution of IQ, SES, GPA (8th) and Science Grade (8th).

(8th grade)	(11th/12th)	R^2	improvement in R^2	F (sex)
1) IQ + SES + GPA + Sci.Gr.	→ Completed Science	.194		
2) IQ + SES + GPA + Sci.Gr. + Sex	→ Completed Science	.285	.091	74.5*
3) IQ + SES + Science Grade	→ Completed Science	.190		
4) IQ + SES + Science Grade + Sex	→ Completed Science	.272	.082	65.8*

*Significant - probability = 0

The results were similar, however. IQ, SES and 8th grade science grade still accounted for 19% of the variance in science-entry (model 3). Again, the addition of the variable sex in model 4 increased the explained variance half again as much by adding an additional 8.2% to the R^2 -- again, a significant increase. Together sex, general ability, social class and junior high school science achievement explained 27.2% of the variance in whether or not students completed an optional science course in the 11th or 12th grade. In other words, about one third of all of the variance explained by the combined variables of ability, achievement, social status and sex can be attributed to sex alone.

As shown in Table 4, separate regression models similar to those in Table 3 were run for males and females separately. There is a large and

Table 4. Separate Regression Models (R^2's) for Males and Females Comparing the Effect of IQ, SES, GPA (8th) and Science Grade (8th) on "Completion of a Science Course" (11th or 12th).

	(8th grade)	(11th/12th)	R^2	
Females	1) IQ + SES + GPA + Science Grade	→ Completed Science	.151	*
Males	1) IQ + SES + GPA + Science Grade	→ Completed Science	.385	
Females	2) IQ + SES + Science Grade	→ Completed Science	.137	*
Males	2) IQ + SES + Science Grade	→ Completed Science	.370	

*Significant Sex Differences -- $p < .05$

significant difference in R^2's between male and female samples. Variables typically used to predict future course decisions such as general ability level, social class and academic performance, are obviously better predictors for males' than for females' completion of elective science courses in high school. For males, IQ, SES and 8th grade science grade together explained 37% of the variance in science-entry in the 11th and 12th grades. For females, these only accounted for 14% of variance in science entry.

Table 5 shows the relationship between early adolescent science achievement and later entry into optional science courses for each sex. Comparing the percentages taking science for each grade level, for males and females

Table 5. Percentages of Females and Males Completing a Science Course (11th or 12th grade) by Science Grade (8th grade).

Science Grade (8th grade)	Females % Taking Science	Females Total N	Males % Taking Science	Males Total N	Sex Diff. Signif.?
A	** 63%	(76)	* 95%	(41)	Yes**
B	* 42%	(112)	** 83%	(92)	Yes**
C	29%	(117)	57%	(70)	Yes**
D-F	* 13%	(38)	** 15%	(46)	No
All Grades	39%	(343)	65%	(249)	Yes**

* $p < .05$; 1-tailed test
** $p < .01$; 1-tailed test

alike, students who received A's in science in the 8th grade were significantly more likely to take an elective science course in the 11th or 12th grade as compared to those who received B's in science in the 8th grade. The seme is true when comparing B with C students, and C with D-F students. However, somewhat surprisingly, maels who received C's in science were about as likely to take science 3-4 years later as were females who received A's

in science (57% vs. 63% -- not significantly different). Clearly, factors other than early adolescent achievement in science influences later entry into advanced optional science courses.

Females were significantly less likely to complete an elective science course in the 11th or 12th grade as compared to males (39% vs. 65%). This held true for most science achievement levels. Comparing males and females who received A's in their 8th grade science course, males were significantly more likely to take science than females (95% vs. 63%). Similarly, differences were found for B and C level students.

One commonly held assumption is that females are less likely to go into science careers because they aren't as capable as males in this area. The data in this study do not support such an assumption. For example, the average science grade received in the 8th grade for males was 2.48 while for females it was 2.65 -- not a significant difference. Hence, by this ability measure, females are not less capable in science than males. And considering that this is the feedback that students received as to ability, females should not consider themselves to be inferior in science.

Discussion

Ability, social class and academic achievement are very commonly used variables important in the career decision process. In this study, these variables accounted for 19% of the variance in high school science entry. However, the addition of the variable sex increased the explained variance in science entry by nearly 50%. Taken together, IQ score, socio-economic status, 8th grade grade-point-average, 8th grade science grade and sex accounted for 29% of the variability of student election of advanced optional science courses in the 11th and 12th grades.

Research in this area of male-female differences suggests that this outcome is of socio-cultural rather than biological origin (Sherman, 1976). One might note, for example, that over a third of the science and engineering professionals and three-quarters of the physicians in the Soviet Union are women (Dushkin, 1977). And Sells' (1976) study at Berkeley found that while 41% and 17% of the Caucasian males and females (respectively) were majoring in mathematics and science, 68% and 45% of the Asian American males and females were math or science majors. The wide range of studies on socio-cultural and social-psychological correlates of science entry and performance would also support this view.

The literature cited earlier suggests the importance of focusing on this early phase of career development in science. When considering the current paucity of women in science-related careers, there are certainly obstacles women face within their careers and career entry, in their graduate school experiences and in theirpursuing of college science majors. But by and large, scientists tend to decide upon careers in science relatively early. And necessarily so. High school math and science courses are virtual prerequisites to any later work in these areas. If students do not take such advanced elective math and science courses in high school, they have, in effect, made an important career decision in mid high school -- they will not, in all probability, later pursue a career in mathematics, the sciences, medicine, engineering or any related area. But males are much more likely to leave these options open to themselves. This and prior research by the authors found that average ability males (as measured by IQ score, general GPA or specific science grades) are as likely (if not more so) to elect optional math and science courses in high school as compared with the highest ability female students. This is not to argue that all females need to be

pushed into science careers. Rather, like high school males, more females (particularly those with higher ability) need to leave a wider variety of options open to themselves for later, more informed career decisions.

The potential benefits from this emphasis on greater female involvement in science can be viewed from several value perspectives. It would certainly seem to be in the interest of society as a whole (e.g., increasing the number of possible scientists and the potential for scientific contributions to society) as well as for its value for women in particular (e.g., increasing women's career options, opening up higher paying/higher status jobs to women). Besides improving and enlarging the future potential pool of scientists, increasing the number of students/females taking elective science courses has the potential for contributing to a more knowledgeable and scientifically aware future adult population of non-scientists. For example in dealing with issues as energy conservation and environmental pollution, in maintaining one's technological conveniences, in dealing with an increasingly computerized society, a more scientifically informed citizenry seems desireable. Women in particular, stand to benefit from improved investigative, mechanical, analytic and problem-solving skills (in which they have traditionally been weak) developed through science training and laboratory work.

Since many students (particularly females) eliminate themselves from possible science careers early -- during high school -- intervention efforts must be expended at this level. A variety of impediments to females' science entry have recently been identified during this adolescent period. For example, in spite of equal math and science ability, females are much less likely than males to have high self-concepts of their math and science ability in junior high school (Kaminski, n.d.). The following would also be of impor-

tance: parental evaluations of math and science ability, parental attention to scientific precocity in daughters, the fostering of science-related hobbies, cultural attitudes on math and science as being a male domain, sex-typed toys related to the development of science skills and interests, parental, teacher and peer academic and occupational expectations and encouragement, counsellors' directives to females on science courses and career possibilities, lack of role models in science, and math and science textbook illustrations and examples (see literature reviews noted previously).

Effort is recently being placed on developing programs for students, teachers and counsellors with respect to science -- for example, booklets on women in science careers to disseminate to high school females (Kreinberg, 1977), math anxiety clinics (Tobias, 1976), workships for high school women (Newton, 1976 -- see Konsin, 1976), work-study positions in science and engineering for high school females (Boyd -- see WEEA, 1977), and dissemination of lists of women scientists available for local presentations to high school students (Menard -- see WEEA, 1977).

Conclusions

Further research is necessary along the lines of this study before accepting these implications beyond a tentative level. We propose to develop and test models with a new longitudinal population of 2000 subjects we are currently following from the 8th grade through high school. This new research will examine the interactive influences of both achievement and SES variables with academic and social climate variables provided to young men and women in school regarding their entry into science careers. We also hope to extend this work to include entry into other career areas.

In any event, we believe, that the findings reported in this study help

to demonstrate an emerging conclusion in the social sciences regarding explanations for the limited number of women who enter the sciences. Sex in this study did not correlate well with either ability as measured by standard IQ tests, achievement level in science courses or socio-economic status. The major implication of this finding when considered in the context of recent past research, is that we need to examine more thoroughly what parents, teachers and other significant influences do to young men and women to produce such differences in career outcomes. The fact that we observed that the males with average grades in science in the 8th grade were nearly as likely to take an advanced science course as were females with A's in science in junior high school indicates that it is time to turn away from obsessions with early ability and achievement levels as a primary explanation of career outcomes to other more social influences. Clearly, it would seem of greater importance to examine and explain sex differences in entry into optional math and science courses rather than searching for ability differences between males and females.

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